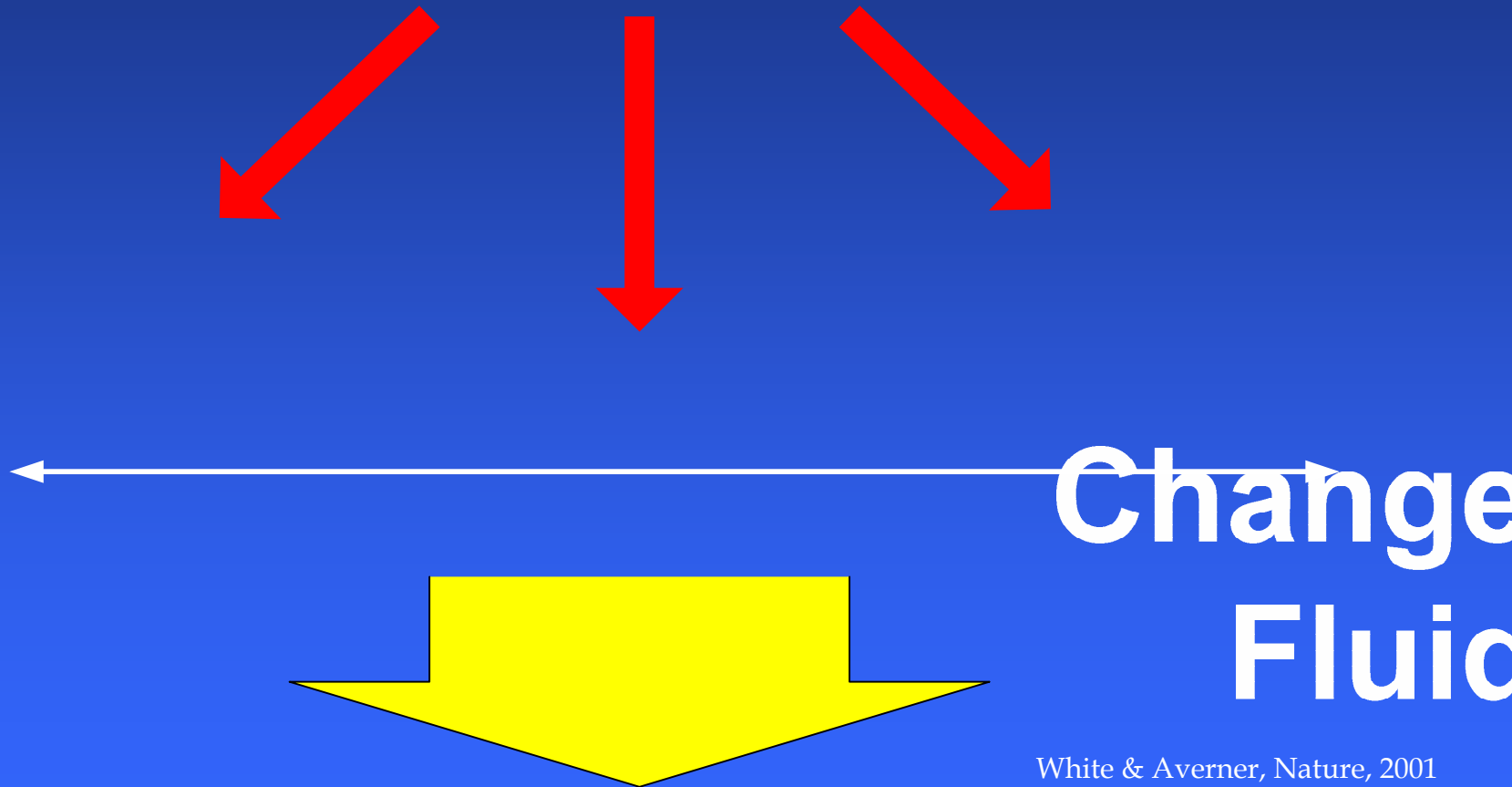


Investment and Return In International Space Life Sciences Research Cooperation

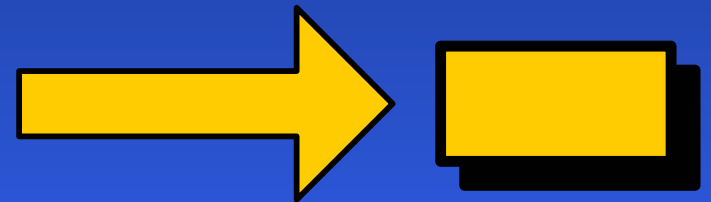
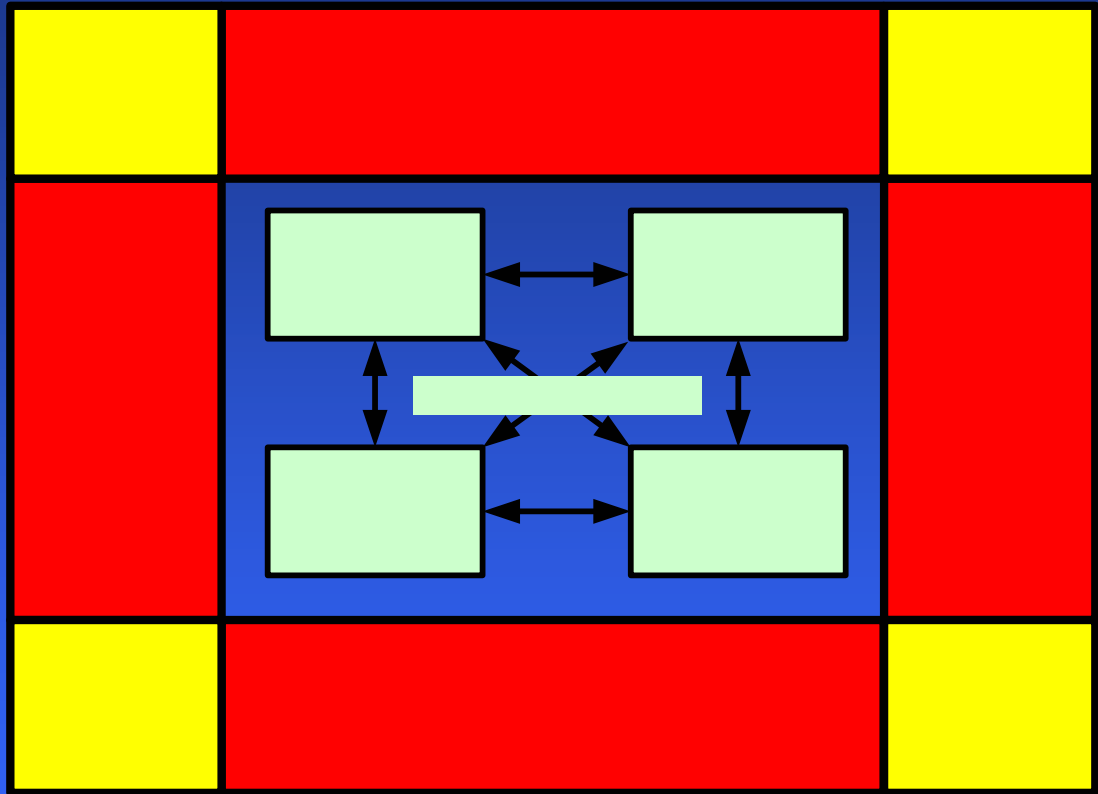
Jancy C. McPhee & Ronald J. White
May 22, 2007



Altered FORCES on the Human Body



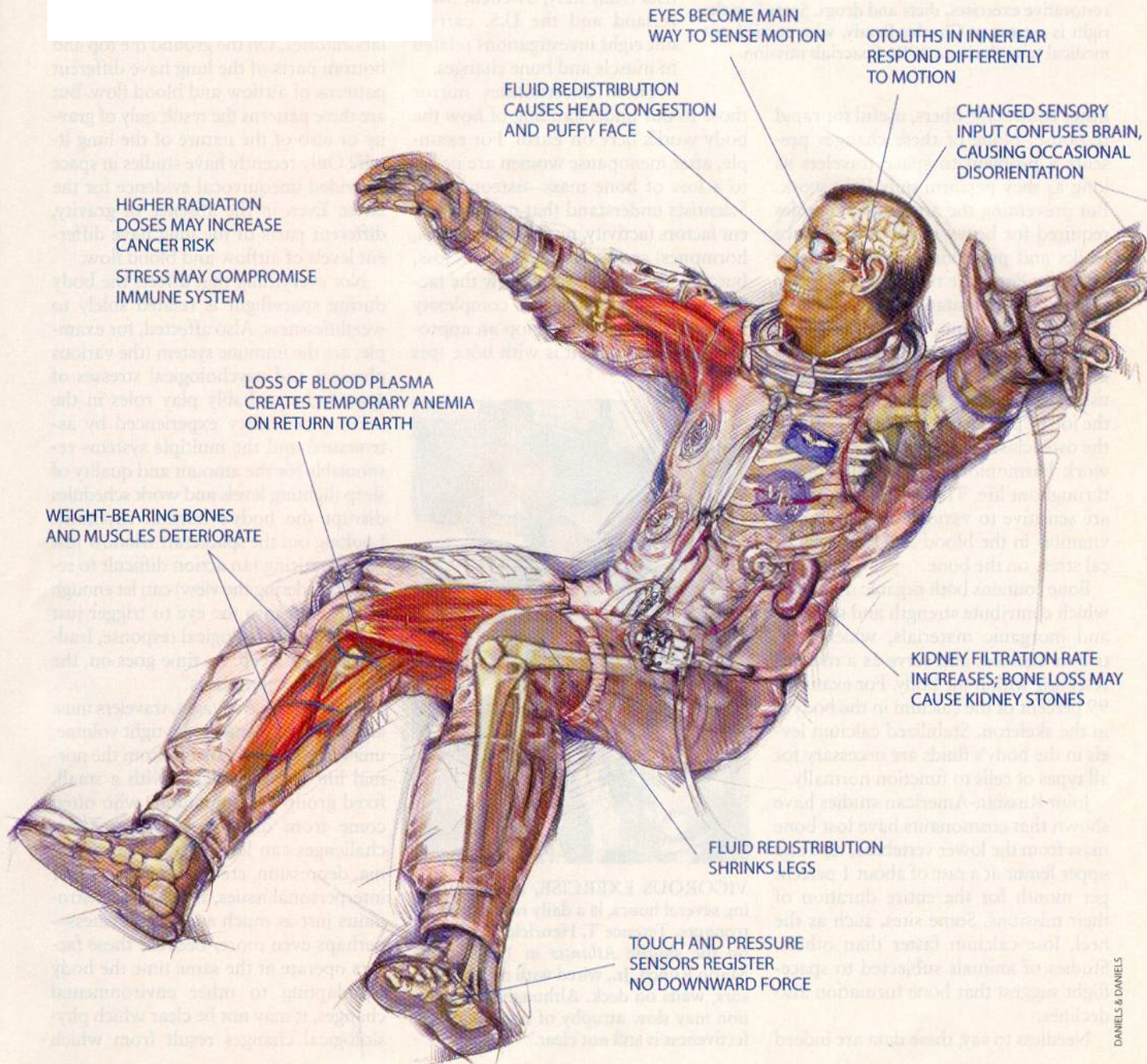
White & Averner, Nature, 2001



**Altered Drug
Usage &**

Altered Psycho

The Effects of Space Travel on the Body



Physiological & Psychosocial Manifestations Associated with Space Flight

Bone

- ↓ Bone mineral content
- ↓ Bone mineral density
- ↑ Urinary calcium
- ↑ Renal stone risk

Skeletal Muscle

- ↓ Skeletal muscle mass
- ↓ Skeletal muscle strength
- ↓ Skeletal muscle endurance
- ↓ Skeletal muscle capillary density

Neurosensory

- ↑ Vestibular disturbances
- ↑ Space motion sickness
- ↓ Sensorimotor function
- ↓ Postural & locomotor stability



Cardiovascular

- ↓ Fluid volume
- ↓ Orthostatic tolerance
- ↓ Aerobic capacity
- ↑ Arrhythmias

Psychosocial

- ↑ Team issues
- ↑ Confinement issues
- ↑ Fatigue
- ↑ Stress
- ↑ Errors
- ↓ Cognitive Function

Environmental

- ↑ Hearing loss due to acoustics
- ↑ Radiation exposure
- ↑ Risk of cataracts/cancers
- ↑ Skin irritations due to microbial growths

Challenges of Performing Space Life Sciences Research

- Flying in Space is Expensive
- Space Flight Experiments are Technically Difficult to Perform
- Access to Space Platforms and Subjects is Limited
- Ground-Based Flight Analog Experiments are also Expensive and Time-Consuming

**Result is Small Number of Data Points
Upon Which to Draw Conclusions**

Levels of International Cooperation in Space Life Sciences Research

- Level 0 – No Cooperation
- Level I – Formal Data Exchange
- Level II – Harmonious Integration of Pre-Designed Experiments
- Level III – Joint Design of Integrated Experiments

Levels of International Cooperation in Space Life Sciences Research

Level 0 – No Cooperation

- Individual proposals reviewed & selected
- Individual protocols executed
- Standard approach in scientific community
- Yields results that are published in scientific papers and reports
- Low-level (but important) scientific integration takes place through review articles and textbooks
- Major problem has to do with the general lack of standardization in the collection of data and thus inability to really compare or pool results
- Additional problem is that often important data is unpublished data and thus not available

Levels of International Cooperation in Space Life Sciences Research

Level 0 – No Cooperation-Examples

- Published research from investigators all over the world is found amongst numerous internationally accessible journals
- Many reviews, for instance:
 - Fregly and Blatteis, eds., Handbook of Physiology, Section 4: Environmental Physiology, Chapter III: The Gravitational Environment, ed. Greenleaf, 1996
 - Huntoon, Antipov, and Grigoriev, eds., Space Biology and Medicine Vol. II, Books 1 and 2, Humans in Spaceflight (Joint US/Russian Publication), 1996
 - Buckey, Space Physiology, 2006
 - Souza, Hogan, and Ballard, Life Into Space: Space Life Sciences Experiments 1965-1990 (Experiment Compendium), 1995

Levels of International Cooperation in Space Life Sciences Research

Level I – Formal Data Exchange

- Agency activity to improve scientific return
- Individual proposals reviewed and selected and individual investigation protocols executed (as in Level 0)
- Individual data sets (including potentially unpublished results), papers and reports are gathered together in a single package and exchanged with other Agencies who have similar research activity
- Major problem has to do with the general lack of standardization in the collection of data and thus often inability to really compare or pool results

Levels of International Cooperation in Space Life Sciences Research

Level I – Formal Data Exchange – Example

- US-Russian Agreements for Joint Data Exchange

Levels of International Cooperation in Space Life Sciences Research

Level II – Harmonious Integration of Pre-Designed Experiments

- Individual proposals reviewed and selected (as in Level 0)
- Synergistic Protocol Developed
- Synergistic Protocol Executed
- Synergy Includes Increased Opportunities for Scientific and Operational Integration
- Use of Standardized Experimental Techniques can Result, Facilitating Exchange and Comparison of Data
- Integrating Already-Formed Detailed Proposals is Very Difficult

Levels of International Cooperation in Space Life Sciences Research

Level II – Harmonious Integration of Pre-Designed Experiments – Examples

- SLS-1 and SLS-2 Mission (Spacelab aboard STS-40 and 58, launched in 1991 and 1993 respectively)
- Ground-Based Studies to Prepare for D-2 Mission (D-2 was Spacelab aboard STS-55, launched in 1993)

Levels of International Cooperation in Space Life Sciences Research

Level III – Joint Design of Integrated Experiments

- Joint Agency Investigator Team
- Team Develops Joint Research Proposal
- Team Proposal Reviewed
- Team Protocol Executed
- Synergy Includes Greatly Increased Opportunities for Scientific and Operational Integration

Levels of International Cooperation in Space Life Sciences Research

- **Level IIIa: Joint Investigator Team Formed from Individual Detailed Proposals Reviewed and Selected**
 - Use of Standardized Experimental Techniques Can Result, Facilitating Exchange and Comparison of Data
 - Integrating Already-Formed Detailed Proposals is Very Difficult
- **Level IIIb: Joint Investigator Team Formed from Individuals Selected (often via Review) Prior to Detailed Proposal Development :**
 - Use of Standardized Experimental Techniques More Likely to Result, Enabling Exchange and Comparison of Data
 - Forming Integrated Proposal Jointly from Initial Investigator Ideas is Less Difficult than as per Level IIIa
 - Good Potential for Multiple Campaigns of Related and Comparable Investigations
 - Good Potential for Coordination of Multiple Sites of Similar Investigations, Potentially Increasing Number of Data Points per Experiment that is Available for Each Partner but at Cost for Research at One Site Only

Levels of International Cooperation in Space Life Sciences Research

Level III – Joint Design of Integrated Experiments – Examples

- Level IIIa (Joint Design of Integrated Experiments Based on Individual Proposals)

Neurolab Mission

(Final Spacelab mission using that module and some middeck Shuttle area, aboard STS-90, launched 1998)

- Level IIIb (Joint Design of Integrated Experiments Based on Investigator Selection without Proposals)

International Multidisciplinary Artificial Gravity (IMAG) Project
(Ground-based project)

Levels of International Cooperation in Space Life Sciences Research

Category	Cost	Benefit
<u>LEVEL 0</u> No Cooperation - Standard Individual Experiments	+	+
<u>LEVEL I</u> Formal Data Exchange	+ ¹ / ₂	++
<u>LEVEL II</u> Harmonious Integration of Pre-Designed Experiments	+++	+++
<u>LEVEL IIIa</u> Joint Design of Integrated Experiments - Based on Individual Proposals	++++	++++
<u>LEVEL IIIb</u> Joint Design of Integrated Experiments - Based on Investigator Selection without Proposals	++	++++

